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## PACIFIC AREA DATA COLLECTION STATIONS

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## PREFACE

This report summarizes NASA Contract NAS5-26889 which provided for the installation of environmental Data Collection Systems at several remotely located sites on islands in the Pacific Ocean. The effort was designed to enhance the ability of the U.S. Geological Survey to collect hydrological information for its Water Resources Management Program.

The Data Collection Station consists of a Data Acquisition System for handling data, a transmitter for uplinking information to the GOES-W geostationary satellite, and a variety of environmental sensors for data accumulation.

The individual Data Acquisition Systems were specified by the U.S.G.S. to meet their requirements and all sensors were supplied by U.S.G.S. Each system was assembled, tested, and deployed on designated islands.

The concept of using microprocessors for handling data at remote sites and relaying it via a satellite link is a cost effective approach. Such systems require high reliability and proven performance in the field.

P & P INDUSTRIES, INC.

DATA COLLECTION PLATFORM FINAL REPORT

NASA CONTRACT #NAS5-26889

I. BACKGROUND

This is the final report for NASA Contract NAS5-26889, which provided for the deployment and installation of automatic meteorological data collection stations at remote sites on islands in the Pacific Ocean. These stations supported an experimental effort of the Water Resources Management Program conducted by the Honolulu office of the United States Geological Survey (U.S.G.S.).

The present method of collecting hydrological data from the numerous U.S.G.S. stations (gage houses) requires a field technician to travel to the site and remove paper tapes from river stage recorders and measure precipitation accumulation collected in storage containers. This data collection is made weekly at easily accessible sites. However, at remote sites the collection interval can be as much as six (6) months. The collected hydrological information is then delivered by hand to a U.S.G.S. central information processing area where it becomes part of the water management studies program.

To improve this system, NASA, in conjunction with the U.S. Geological Survey, developed an information handling system that uses an integrated multiple access Data Collection System to collect, store and electronically relay data to a central U.S.G.S. location. In addition to eliminating hand collection of the data, the new system provides the U.S.G.S. with an additional capability to monitor sudden environmental changes.

Under the contract, a site survey was conducted in March 1982 to determine the suitability of each location. As a result, Data Collection Stations were installed at the following sites during the period from April 1982 to March 1983:

Wailuku River, Hawaii  
Honopou Stream, Maui  
Waihee Stream, Oahu  
Moanalua Valley, Oahu  
Waikele Stream, Oahu  
Kipapa Stream, Oahu  
Mt. Waialeale, Kauai  
Waimea River, Kauai

\*Pago Stream, American Samoa  
Mt. Tolenpwoipwoi, Ponape  
\*Mt. Chachao, Guam

\*NOTE: Sites on Samoa and Guam were changed after survey due to physical site limitation.

## II. DESCRIPTION

The new Data Collection Station accumulates data from various meteorological and hydrological sensors, performs signal processing on that data and then records it in storage buffers for later transmission to the geosynchronous NASA GOES-WEST satellite which is centrally located over the Pacific Ocean. The GOES satellite then retransmits the data to the U.S.G.S. in Honolulu. The major component in the system is the Data Acquisition System, Model 540A manufactured by Handar Corporation. This unit is contained in a NEWA 4 weatherproof enclosure and consists of a microprocessor for data handling, a 12-bit analog to digital converter, meteorological sensor interfaces, a 401 MHz GOES transmitter and 20 AH gel-cell battery. Other station components include a yagi antenna, a 400 ma solar panel and various hydrological and meteorological sensors.

The Data Collection Stations are installed at U.S.G.S. "gage houses", which are plywood structures, approximately 4' x 4' x 7', that are usually constructed along the banks of streams or in prepared clearings.

## III. TESTING

The DCP components were received between April 1982 and October 1982. The data acquisition systems were obtained directly from the manufacturer. The meteorological and hydrological sensors were supplied as Government Furnished Equipment (G.F.E.) from the U.S. Geological Survey. System level testing began in early October 1982.

Each Data Collection Station was assembled in accordance with U.S.G.S. requirements including its antenna, solar panel and specified sensor configuration. The fully assembled station was then programmed using the Handar 545A Programming Test Set. Each sensor was manually actuated to simulate data and the resulting output was stored in the Data Acquisition System. This output data was then uplinked using the transmitter at three (3) hour time intervals to the GOES-WEST Satellite. The GOES-WEST satellite then re-transmits the data to the NOAA/NESS facility located in Suitland, Maryland. NESS is the central information processing center for GOES data

and they confirmed that the data was acceptable and that the accuracy of the time transmission was proper. After the operational testing was completed all system cabling and connectors were tested for continuity. The solar panel was checked to insure acceptable output levels. Following the testing the Contract Technical Officer, or his designated representative, accepted the equipment and the Data Collection Station was shipped to the U.S.G.S. in Honolulu, Hawaii.

In Honolulu, the Data Collection Stations were again tested using the same procedure used at the contractors plant. The test results were confirmed using the DCS Ground Station located at the U.S.G.S. Honolulu office. A second acceptance form was completed as each DCP successfully completed testing.

During testing programs at the contractor's plant and at the U.S.G.S. in Honolulu only two discrepancies were found. One ADR Water Level Recorder was found to be defective, and the identification (ID) code for the Waimea River station could not be transmitted to the satellite. The ADR Water Level Recorder was replaced. The problem with the ID code was traced to a flaw in the manufacturer's programming of the EPROMS in the micro-processor. Handar, the manufacturer, supplied replacement EPROM cards with upgraded programs for all the DATA Acquisition Systems. This replacement effort caused a major change in the DCP installation schedule. Later, a faulty RAM chip was discovered on the replacement EPROM cards causing serious problems in maintaining continuous station operation.

#### IV. INSTALLATION

The first Data Collection Stations were installed at Waikele Stream and Moanalua Valley in April 1982 on the island of Oahu. NASA and U.S.G.S. personnel assumed responsibility for the installations at these two stations.

The Waikele Stream gage house at Waipahu is located about one-half hour drive from the U.S.G.S. office in downtown Honolulu. It is primarily a demonstration site with a large compliment of meteorological and hydrological sensors.

The Moanalua Valley gage house is located in the interior of Oahu requiring a two hour hike through rough terrain and heavy undergrowth. This DCS is configured for rainfall measurement only.



Vandalism was a problem at Moanalua despite it's remote location. The station stopped transmitting shortly after the initial installation and a return trip discovered that the solar panel was missing. Normally the panel was mounted on the antenna mast but because of its vulnerability, U.S.G.S. decided to recess the panel into the gage house roof and cover it with glass despite the reduced charge potential associated with this type installation. No additional panels were removed from Moanalua after this modification.

In mid-November Data Collection Platforms were installed at Kipapa Stream and Waihee Stream, both located on the island of Oahu.

The Kipapa Stream gage house, located near Wahiawa, required a strenuous backpacking trip over very steep terrain. Six trips were required to this station to make it operational. The Kipapa DCS was originally planned to be powered from a commercial source, however the power was out and a return trip was made to install a solar panel. During installation, problems developed with the ADR tape, the tip bucket, the MET card and the battery. All required return trips before proper operation was achieved. The Kipapa DCS measures river water level and rainfall.

The Waihee Stream gage house near Kahaluu was a drive-up site on the eastern side of Oahu. This Data Collection Station monitors water level and rainfall and because of its accessibility required the recessed solar panel mounting to discourage vandalism. No difficulties were experienced during this installation.

In late-November 1982 two Data Collection stations were installed on the islands of Maui and Hawaii.

The Maui site was located on the Honopou Stream near Huelo and was a drive-up site. Again, because of accessibility, the solar panel was recessed. This DCS records only the stream water level data.

A return trip to the Honopou gage house was necessary to replace a defective ADR Recorder and a discharged battery. The glass-covered, recessed solar panel mounting used at Honopou and at Waihee may be contributing to the battery discharge problem, however this question has yet to be resolved.

On the island of Hawaii, the DCS was installed at the Wailuku River gage house at Piihonua. This station monitors water level and rainfall in addition to three water quality parameters; specific conductance, water temperature and dissolved oxygen content. Even though this was a drive-up site, the installation required three days of labor and testing before proper operation was achieved.

In late November 1982 two installations were scheduled on the island of Kauai, but both were postponed because of the extensive storm damage on the island caused by hurricane Iwa.

Samoa was selected as an alternate site and arrangements were made for the installation in early December. The original installation site was located at Afuelo Strait on the northern coastline. This location was difficult to reach so the U.S.G.S. chose a more accessible location on Pago Stream at Afono. A larger gage house was constructed at this site to house the new Data Collection System as well as the existing water level recorder. U.S.G.S. requested that the present data gathering recorder be maintained as a back-up for the new electronic system (DCS).

The Pago Stream installation monitors the stream water level and area rainfall. The Data Collection System operated flawlessly for two days before a capacitor failed in the 540A Data Acquisition System. A replacement 540A was installed and the Pago Stream DCS was brought back on the air.

On returning to Honolulu, a meeting was held with representatives from the U.S.G.S., NASA and P & P Industries. A decision was made to postpone the four remaining installations (Guam, Ponape and two (2) sites on Kauai) until February 1983. There were two reason for this delay. The hurricane damage on the island of Kauai prevented any further efforts there for the immediate future. In addition the unavailability of 540A Data Acquisition Systems due to the incomplete replacement of the EPROM cards by the manufacturer was a factor. Furthermore, the component failure in the unit at Pago Stream, Samoa raised the question of reliability, because an identical malfunction occurred a few months earlier at the Moanalua Valley site. The cause of the failure was traced to the use of an underrated capacitor by the manufacturer. Properly rated replacements for all the Data Collection Platforms were supplied by the manufacturer.

During the December 1982 to February 1983 time period the remaining replacement EPROM cards

were received from Handar Corp. Also during the period six of the seven Data Collection Stations that had been installed developed problems and stopped operating. The cause was traced to an improperly connected power cable. Through the coordinated efforts of U.S.G.S., NASA, the manufacturer and the contractor, five of the six stations were placed back in service. This required reconfiguring the system cabling, replacing the EPROM card and the underrated capacitor. Repair of the sixth station at Pago Stream on Samoa was scheduled for March 1983.

During the period from February to March 1983 before any additional installations were scheduled the underrated capacitors and faulty EPROM cards were replaced in all the remaining Data Acquisition Systems.

The first installation of this period was scheduled for the island of Guam. This Data Collection Station was originally planned for installation along the Imong River near Agat, but this site was unsuitable because of its location in a valley. A change was necessary because of the low elevation look-angle ( $0.8^{\circ}$ ) with respect to the GOES-WEST satellite. A new site was selected on 850 foot Mt. Chachao that provided a less-restricted view of the horizon and a higher probability of successful transmission to the satellite. The Yagi antenna was mounted 15 feet above the gage house in order to see over the vegetation. This Data Collection Station was configured for rainfall data using an ADR water level recorder and storage container. Following system installation the U.S.G.S. DCS Ground Station confirmed successful transmission and reception of the data.

From Guam, the installation team proceeded to the island of Ponape, located 1,000 miles to the southeast in the Federated States of Micronesia. The selected DCP site was at an elevation of 1400 feet on Mt. Tolenpwoipwoi which is located on the southern side of the island. All equipment was delivered using small boats. Then, the equipment was packed up to a base camp using manpower and water buffalo. The following day, the installation team moved up to the Tolenpwoipwoi gage house and began the installation. This Data Collection Station was configured to monitor area rainfall and barometric pressure. Following the installation the U.S.G.S. office in Guam confirmed successful operation of the station as reported by the Honolulu U.S.G.S. DCS Ground Station.

Two Data Collection Stations were installed on the island of Kauai in early March. The first station was installed at the Waimea River gage house near Waimea Canyon. This station was equipped for monitoring area rainfall and river level. The gage house was some distance from the river necessitating the use of a nitrogen bubble monometer powered by 12 volt wet cell batteries. Because of overhanging vegetation the "catchman", a funnel-shaped device used for collecting rainfall was mounted on a hillside behind the gage house. The normal configuration for this device was a roof mounting.

The second installation was at the summit of Mt. Waialeale, a 5,000 foot peak in the center of the island. Access to this remote site was possible only by helicopter. Mt. Waialeale is known as the wettest place on earth with an annual rainfall of 600", consequently the area is shrouded by cloud cover most of the time. This cloud cover severely limited helicopter operation. The installation team was ferried to the Waialeale gage house early in the morning and, working quickly, was able to complete the installation and get out just before the clouds would have prevented the helicopter from landing. The Mt. Waialeale Data Collection Station is equipped with sensors for monitoring rainfall, barometric pressure, wind speed and direction, and air temperature. The Honolulu U.S.G.S. DCS Ground Station confirmed the successful transmissions from both Waimea River and Mt. Waialeale Data Collection Stations.

On return to Honolulu, the U.S.G.S. reported that three of the previously installed stations at Waikele, Waihee and Honopou Stream had stopped operating. The three stations required replacement of the microprocessor card in the 540A Data Acquisition System. In addition the units at Honopou and Waihee needed new batteries. A failure analysis of the faulty microprocessor cards indicated that the problem was a defective RAM chip and not a programming error on the EPROM as experienced earlier. The manufacturer quickly replaced the faulty cards and the sites were made operational.

The trip scheduled to Samoa for March was made in April. The primary purpose was the replacement of the previously installed 540A Data Acquisition System with an upgraded unit containing a new EPROM card and a properly rated capacitor. The rework went smoothly and successful transmission was confirmed with the Programming Test Set.

The installation program was completed at this point with all stations in full operation.

#### V. TRAINING

The contractor provided on-site informal training and instruction on the operation and maintenance of the Data Collection Stations to U.S.G.S. personnel at each installation site. A simplified Field Programming Guide was prepared that provided a step-by-step procedure for reprogramming the 540A Data Collection Station. This guide was designed to permit relatively untrained personnel to program the DCS for operation. This is the most complex aspect of maintaining and operating the DCP station.

#### VI. CURRENT STATUS

As of the date of this report, two Data Collection Stations have developed problems, and U.S.G.S. personnel are in the process of servicing the following sites:

Mt. Chachao, Guam	ID 163145C8
Mt. Waialeale, Kauai	ID 1631202E

#### VII. SUMMARY

The concept of using microprocessors and transmitters to automatically process and relay meteorological data from remote collection sites through a geostationary satellite to a central collection and analysis center is a cost-effective approach. Development problems encountered were not unusual in nature, however, reliable operation of the system will require that further engineering effort be made to resolve them.